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Cinnamon et al.

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(54) **SOLAR PANEL MECHANICAL CONNECTOR AND FRAME**

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H02S 40/36 (2014.01)

(52) **U.S. Cl.**
CPC ***H02S 30/10*** (2014.12); ***H02S 40/36*** (2014.12)

(58) **Field of Classification Search**
CPC F24J 2/52; F24J 2/5211; F24J 52/52; F24J 52/5203; F24J 52/5207; F24J 52/5211; F24J 52/523; F24J 52/526; F24J 52/5262
USPC 136/244, 243; 52/173.1
See application file for complete search history.

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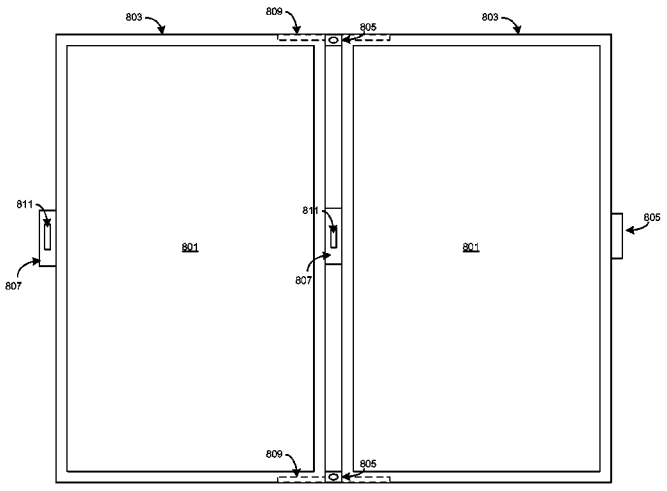
(57) **ABSTRACT**

A design is described for solar panel that allows for modular installation and efficient removal of panels irrespective of the panel's relative location in an array arrangement. A system is provided that includes a plurality of modular panels (such as solar power panels). These panels are rimmed by frames featuring one or more exterior-facing, grooved channels. A first channel—which may be used to mount the panel, and which replaces traditional railing installation systems—and a second channel that is configured to allow movement of one or more panel splices used to secure the panels together. Integrated electrical connection interfaces are provided on opposite side surfaces of the frames to couple with the electrical connection interfaces of adjacent panels to establish an electrical path between them. A spacer component may be inserted between panels to provide access to the electrical connection interfaces; support and rigidity to the joined panels; a grounding path between the panels; and, when combined with the panel splices, to align the panels to prevent damage to the electrical connection interfaces.

27 Claims, 11 Drawing Sheets



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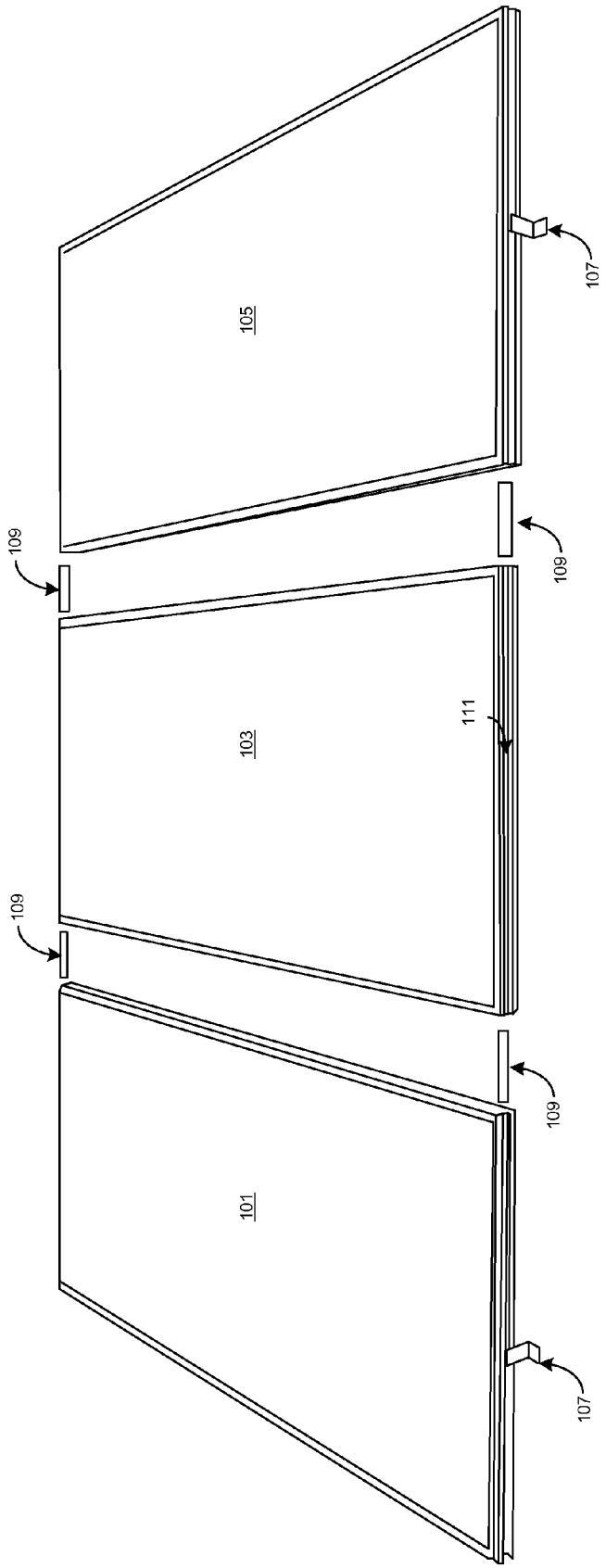


Figure 1

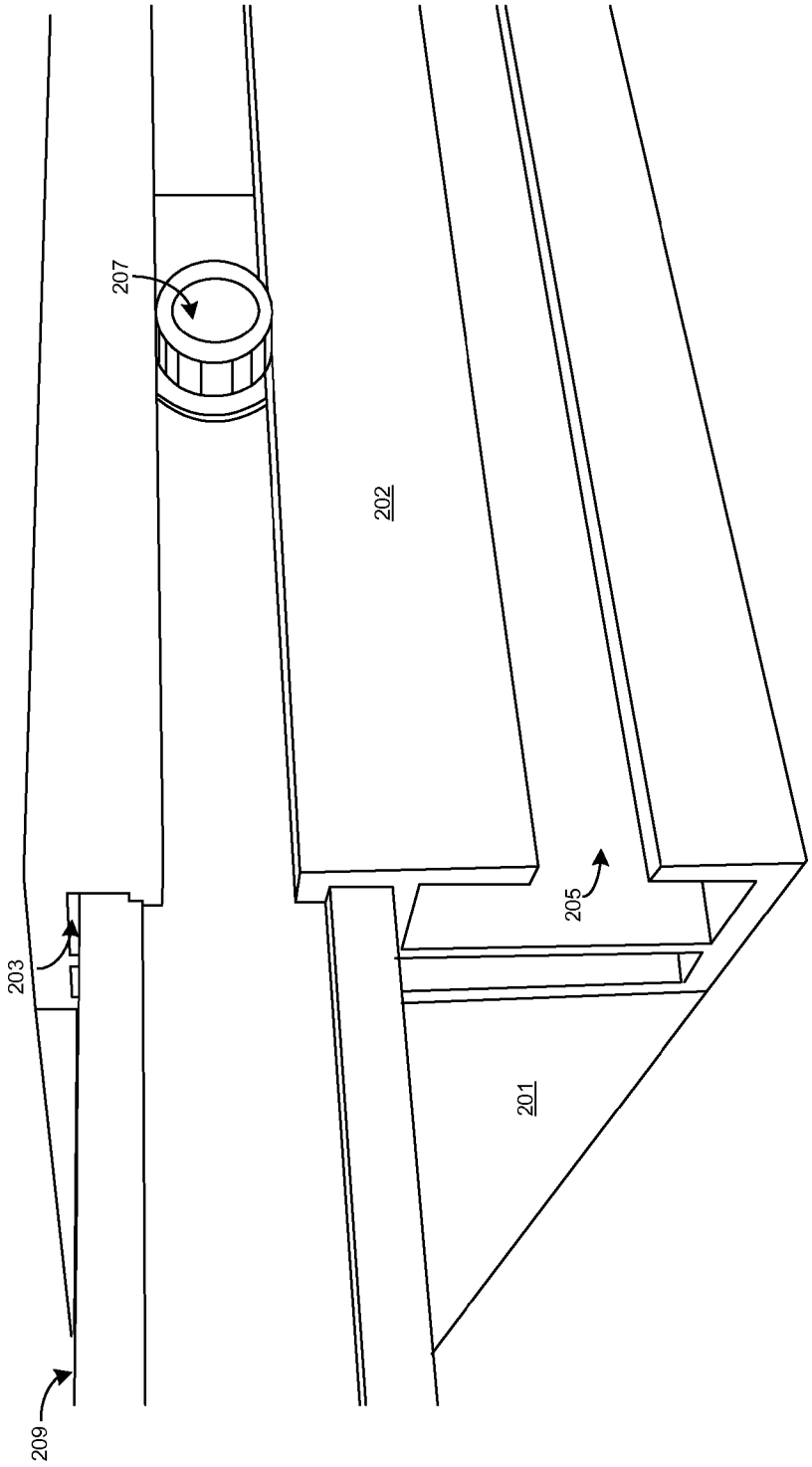
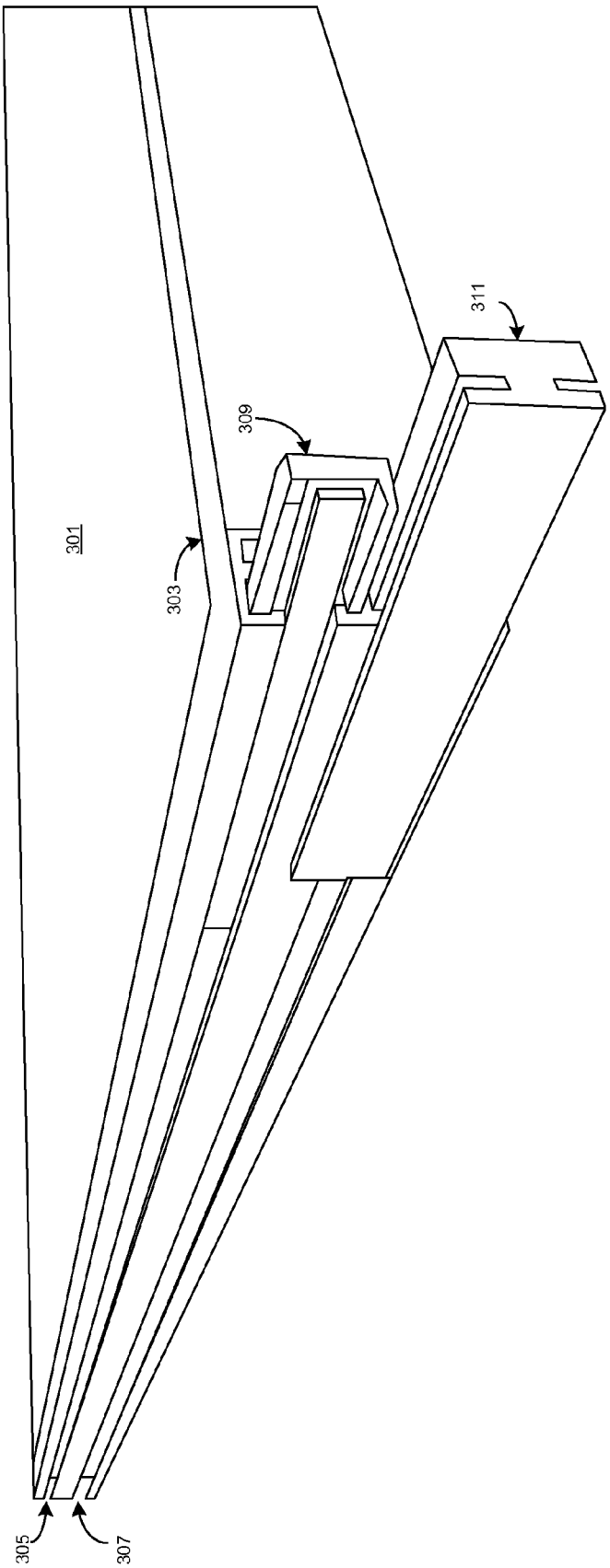


Figure 2



300

Figure 3

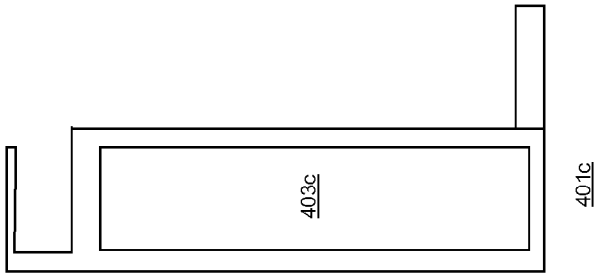


Figure 4c

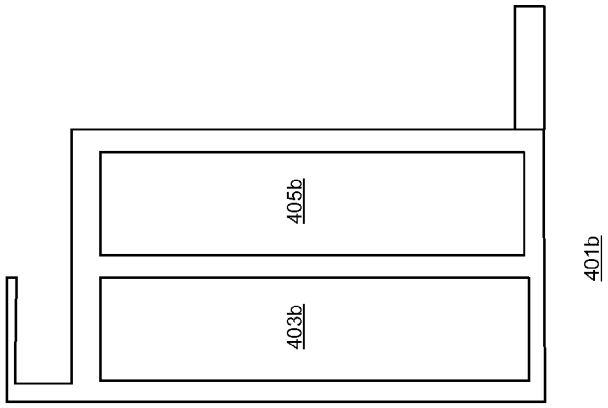


Figure 4b

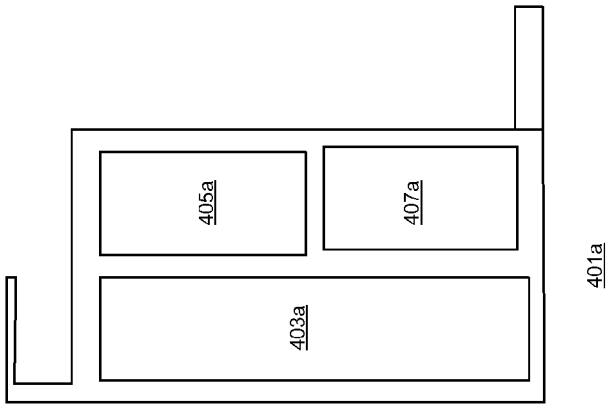


Figure 4a

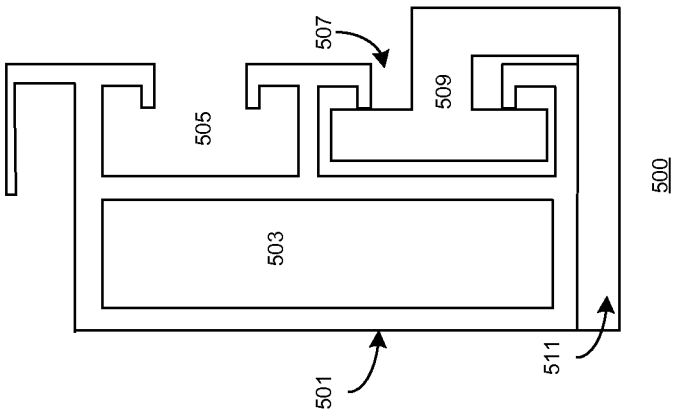


Figure 5

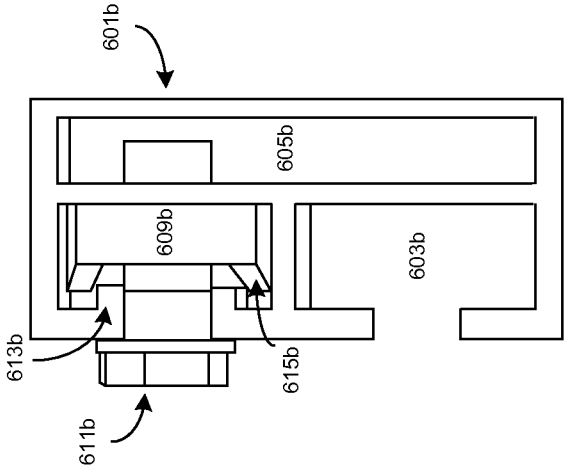


Figure 6b

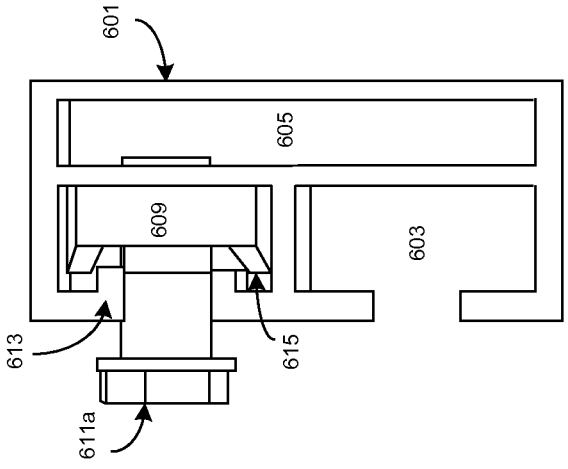


Figure 6a

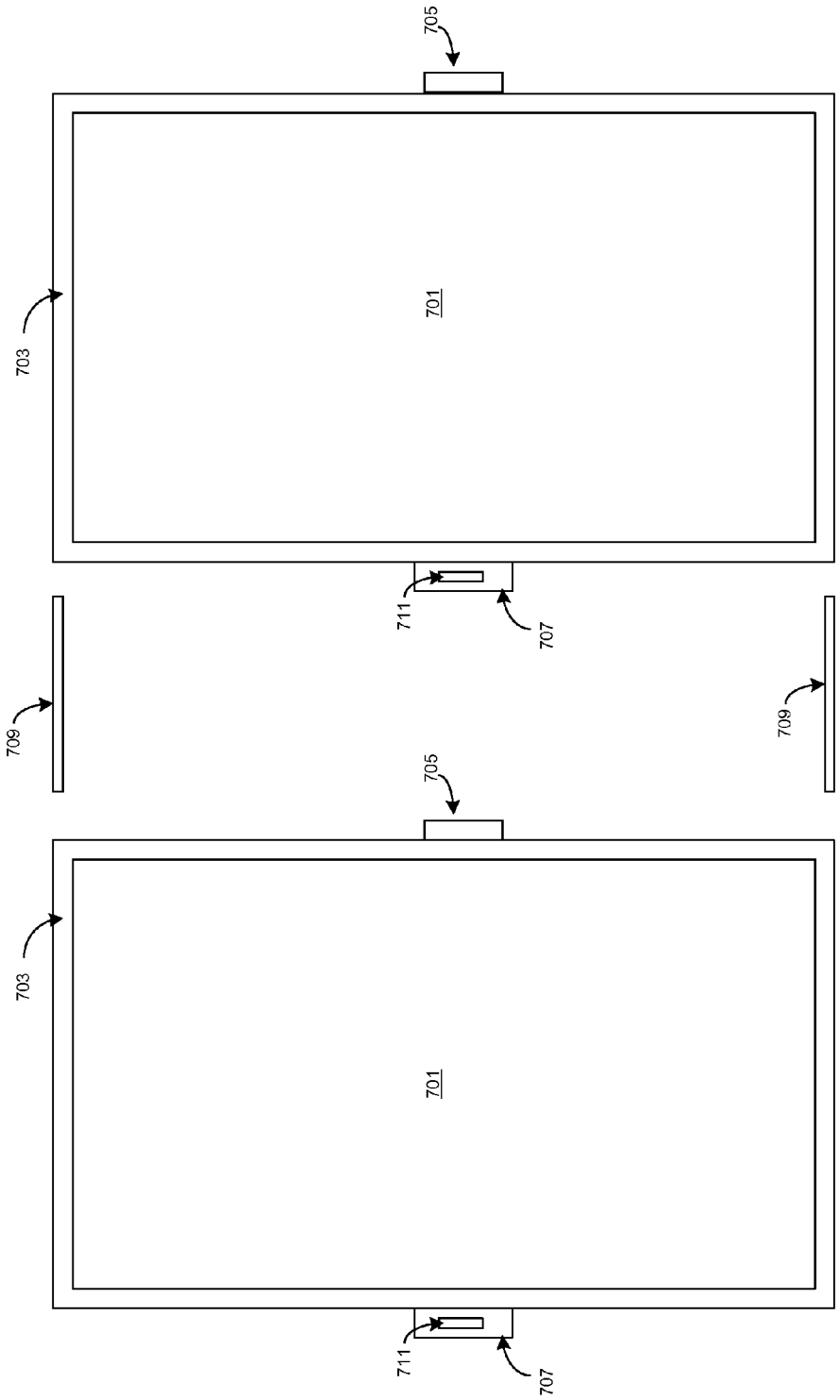


Figure 7

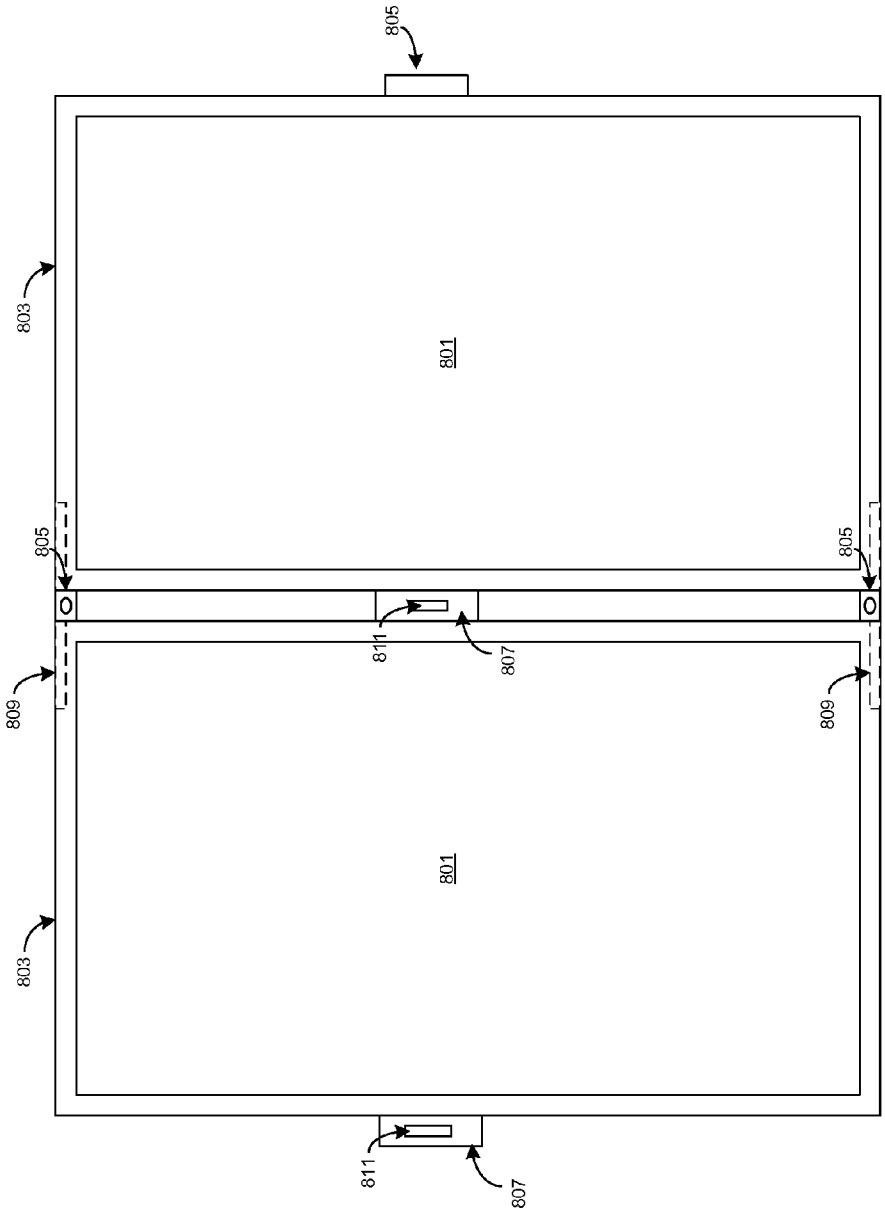
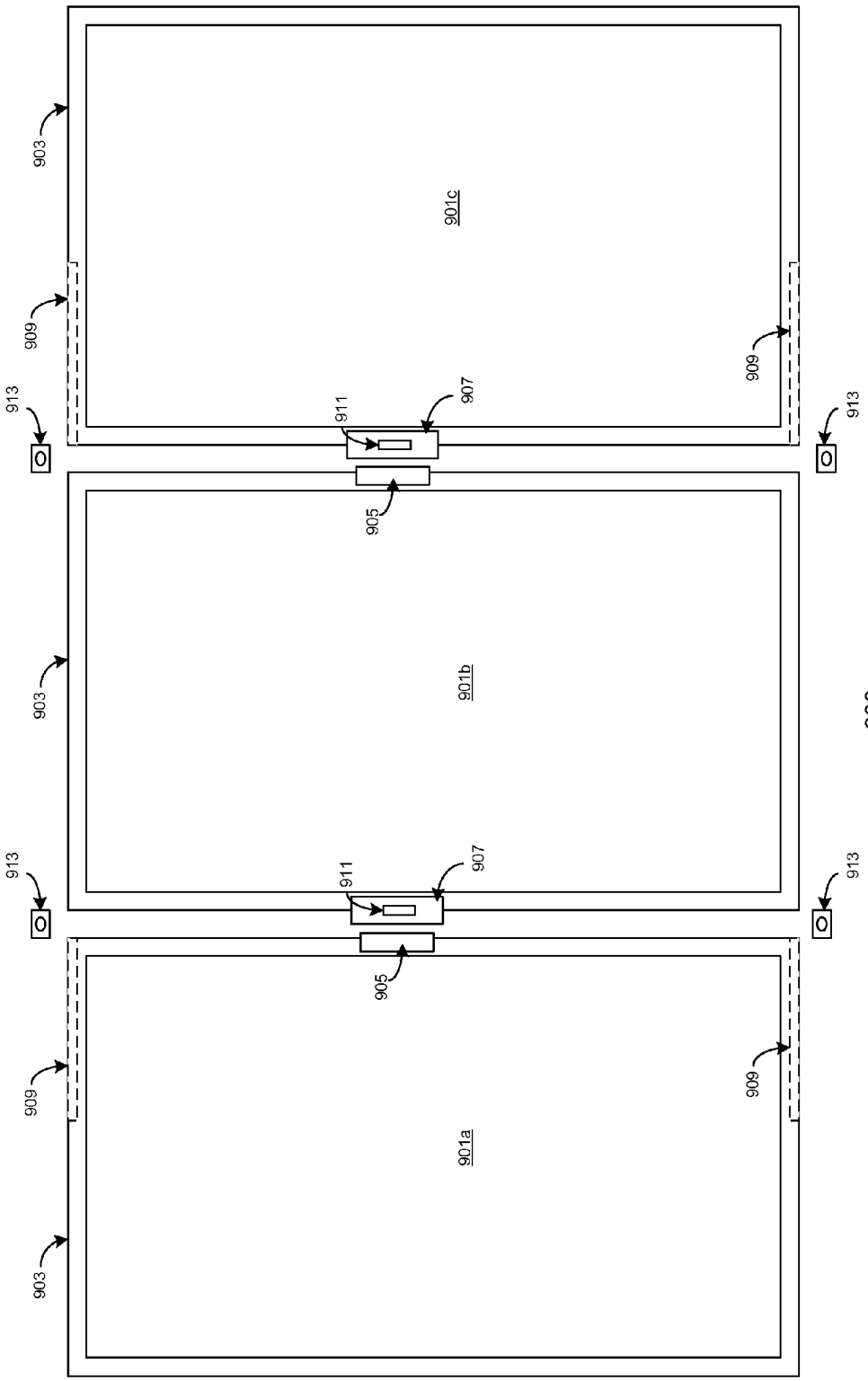


Figure 8


903
901c
909
909
913
911
907
913
905
903
901b
900
913
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913
905
909
909
901a
903

Figure 9

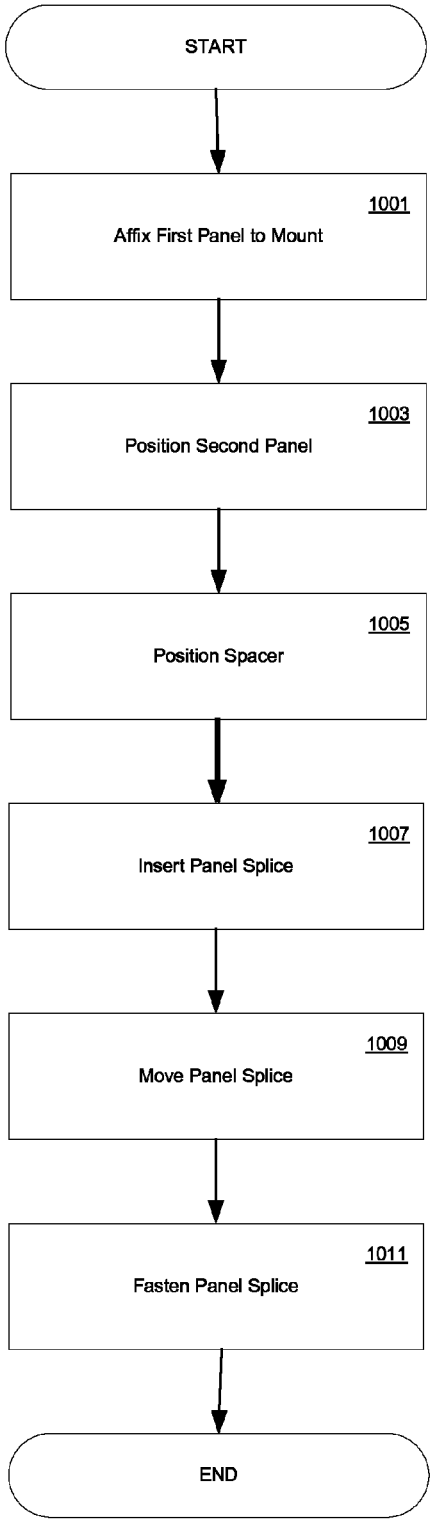
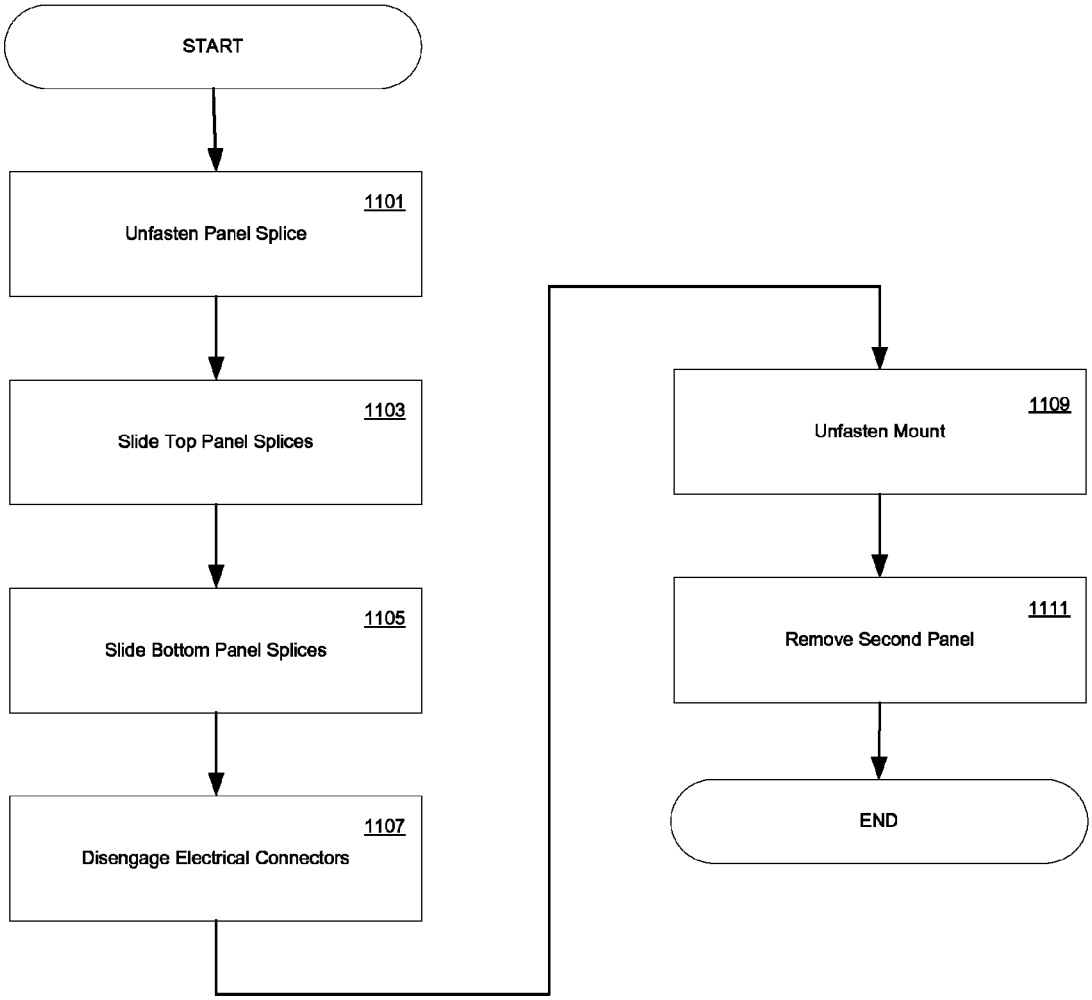

START
1001
Affix First Panel to Mount
1003
Position Second Panel
1005
Position Spacer
1007
Insert Panel Splice
1009
Move Panel Splice
1011
Fasten Panel Splice
END
1000

Figure 10



1100

Figure 11

SOLAR PANEL MECHANICAL CONNECTOR AND FRAME

BACKGROUND

Recently, concerns over the long-term availability and pollutive effects of traditional energy sources like coal, natural gas, and nuclear power has led to increased interest and development of renewable energy sources. Even more recently, renewable energy sources, which include hydroelectric, wind, solar, geothermal and biomass have been introduced as supplements to traditional energy sources in major business and industry sectors. In some instances, solar powered energy sources have even become the primary energy source for some residences.

Typically, solar power generation for residential establishments involve installing large solar panels on rooftops. These solar panels absorb the solar radiation and convert the absorbed energy into electricity which can be used to power the residence. However, installation of these panels can be complex and/or difficult due to their size. Generally, a mounting system is first installed, and secured against specific locations (e.g., against rafters). A series of rails are then put in place in the mounting system (typically in a grid-like arrangement). The solar panels themselves are then securely affixed to the rails and, eventually, to neighboring panels via mechanical and/or electrical connectors.

However, the railing system presents additional expenditures due to materials and transport costs of the rails themselves. As a solution to this, solar panels were developed that were capable of being installed directly to mounting systems without the need for rails. In order to maintain the same stability and security, the solar panels are mechanically affixed to each other (typically in series), using a mechanical connectors, sometimes implemented as cylindrical rods or trapezoidal beams. Generally, these connectors consist of rigid, threaded connectors, often positioned in short tunnels within the interiors of frames of two neighboring rectangular panels. The connectors are inserted into a first panel, and then to a second panel on the opposite end of the splice. Initially, the connectors protrude into each panel insecurely. Subsequently, the connectors may be manually tightened to both panels—often in a user-intensive process—which increases the rigidity of the connection. However, according to such a solution, the connectors are generally very difficult to access while the panels are in position.

Thus, while obviating the requirement for rails, this solution presents significant problems of its own. Specifically, panel removal can become exceedingly difficult, particularly in the case of "middle" or non-end panels in a grid or panel array. Since there is generally only a small amount of space between neighboring panels, there is often insufficient clearance to completely disengage a splice from the panel to be removed. Moreover, specialized tools are commonly required to insert the splices or other connectors. As such, removal of a specific target panel may actually require the initial removal of several intervening panels in the same row or column (or other orientation). Naturally, this is both an inefficient and extremely time consuming process.

Another conventional solution has been proposed that positions the connectors along the exterior of the frame, with the connectors being capable of being moved along the perimeter in a single grooved channel. However, the channel is also used to affix each panel to mounting points of the mounting system. Thus, movement of the connectors is limited to the lengths of the frames between mounting points. The limited mobility can present problems during removal themselves.

SUMMARY

This Summary is provided to introduce a selection of concepts in a simplified form that is further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

In the following embodiments, a design is described for solar panel that allows for modular installation and efficient removal of panels irrespective of the panel's relative location in an array arrangement. A system is provided that includes a plurality of modular panels (such as solar power panels). These panels are rimmed by frames featuring one or more exterior-facing, grooved channels. A first channel—which may be used to mount the panel, and which replaces traditional railing installation systems—and a second channel that is configured to allow movement of one or more panel splices used to secure the panels together. Integrated electrical connection interfaces are provided on opposite side surfaces of the frames to couple with the electrical connection interfaces of adjacent panels to establish an electrical path between them. A spacer component may be inserted between panels to provide access to the electrical connection interfaces; support and rigidity to the joined panels; a grounding path between the panels; and, when combined with the panel splices, to align the panels to prevent damage to the electrical connection interfaces.

According to another embodiment of the present invention, a method is provided to install a series of modular panels. According to such an embodiment, splices can be used to secure panels together by sliding the splice into a proper position along the exterior of two panel frames. For example, the splice may extend in substantially equal proportion into each of the second channels for the two adjoining panels. Once the splice is properly positioned, the splice can be affixed into to each frame (via a bolt or screw for example) to provide additional security and stability. In one or more embodiments, the splice may also be positioned through a channel of a spacer, aligned against the exterior of the two frames and inserted in between.

According to yet another embodiment, a method is provided to remove a modular panel. According to such an embodiment, a securing splice may be disengaged from a frame (by reversing the securing means, for example). Once unsecured, the splice may be slid into position away from the panel to be removed, e.g., to be entirely or substantially entirely deeper into the second channel of a neighboring panel. This process may be performed for each splice used to secure the target panel. Once the splices are repositioned, an electrical connector which may have been used to electrically couple the panel with adjacent panels is also disengaged, whereupon the panel may be lifted up and removed, without readjusting the position of its neighboring panels.

BRIEF DESCRIPTION OF DRAWINGS

The accompanying drawings, which are incorporated in and form a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention:

FIG. **1** depicts an exemplary system for coupling a plurality of solar panels, in accordance with various embodiments of the claimed subject matter;

FIG. **2** depicts an exemplary configuration of a panel frame and panel splice, in accordance with various embodiments of the claimed subject matter;

FIG. **3** depicts an exemplary configuration of a solar panel with a pair of panel splices, in accordance with various embodiments of the claimed subject matter;

FIG. **4***a* depicts a cross-section of an exemplary panel frame with three channels, in accordance with various embodiments of the claimed subject matter;

FIG. **4***b* depicts a cross-section of an exemplary panel frame with two channels, in accordance with various embodiments of the claimed subject matter;

FIG. **4***c* depicts a cross-section of an exemplary panel frame with one channel, in accordance with various embodiments of the claimed subject matter;

FIG. **5** depicts a cross-section of an exemplary panel frame and panel splice with a shelf configuration, in accordance with various embodiments of the claimed subject matter;

FIG. **6***a* depicts a cross-section of an exemplary panel frame and panel splice with a fastening mechanism in an unfastened alignment, in accordance with various embodiments of the claimed subject matter;

FIG. **6***b* depicts a cross-section of an exemplary panel frame and panel splice with a fastening mechanism in an fastened alignment, in accordance with various embodiments of the claimed subject matter;

FIG. **7** depicts an exemplary illustration of a plurality of panels, in accordance with various embodiments of the claimed subject matter;

FIG. **8** depicts an exemplary illustration of a plurality of panels mechanically coupled by a plurality of splices, in accordance with various embodiments of the claimed subject matter;

FIG. **9** depicts an exemplary illustration of a plurality of decoupled panel, in accordance with various embodiments of the claimed subject matter;

FIG. **10** depicts a flowchart of an exemplary process for coupling a plurality of panels, in accordance with various embodiments of the claimed subject matter; and

FIG. **11** depicts a flowchart of an exemplary process for removing a panel between a plurality of adjacent panels, in accordance with various embodiments of the claimed subject matter.

DETAILED DESCRIPTION

Reference will now be made in detail to the various embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings. While described in conjunction with these embodiments, it will be understood that they are not intended to limit the disclosure to these embodiments. On the contrary, the disclosure is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the disclosure as defined by the appended claims. Furthermore, in the following detailed description of the present disclosure, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be understood that the present disclosure may be practiced without these specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail so as not to unnecessarily obscure aspects of the present disclosure.

Specific embodiments of the invention will now be described in detail with reference to the accompanying figures. Like elements in the various figures are denoted by like reference numerals for consistency.

In the following detailed description of embodiments of the invention, numerous specific details are set forth in order to provide a more thorough understanding of the invention. However, it will be apparent to one of ordinary skill in the art that the invention can be practiced without these specific details. In other instances, well-known features have not been described in detail to avoid unnecessarily complicating the description.

In the following embodiments, an embodiment is described for an approach to modular solar panel installation and removal that provides quick and efficient removal while maintaining stability and security during operation.

As depicted in FIG. **1**, an exemplary system **100** is depicted for coupling a plurality of rectangular solar collecting panels, in accordance with various embodiments of the claimed subject matter. In one or more embodiments, the plurality of panels (e.g., panels **101**, **103**, and **105**) may include solar panels, each being implemented as one or more solar cells. Composition of the solar cells may vary according to various implementation, and may include (but are not limited to): crystalline-silicon solar cells, thin-film solar cells, amorphous-silicon solar cells, or a combination of two or more compositions, for example. The panels may be electrical solar panels in one embodiment.

In one or more embodiments, the solar panels (**101**, **103**, **105**) may be mounted to a roof, other relatively flat surface, or open structures such as a carport or ground-mounted array. Mounting may be performed by affixing portions of a panel (e.g., a panel frame) to mounting points **107**. The mounting points **107** may be implemented as hinges or other vertical outcroppings and configured to be fastened to a mounting system installed (typically with a flashing) into the roof. In one embodiment, mounting points **107** may be positioned to correspond to the location of rafters or other secured points in a building or establishment. As shown in FIG. **1**, the perimeter of each panel includes one or more channels **111**. These channels can, in various embodiments, be implemented as grooves along entire (or substantial portions of) lengths of the exterior surface of the panel's frame, allowing for the free movement and positioning of elements within the channels. The channels may themselves be disposed along any of a side, top, or bottom surface of the frame, or a combination of surfaces. In one or more embodiments, panel splices **109** may be freely positioned along the channels on opposite sides of two or more adjacent panels, to provide rigidity, panel alignment, and a grounding path between panels. According to further embodiments, a separate channel or groove may be used to position the mounting point **107** at the designed location.

Exemplary Panel Configuration

As depicted in FIG. **1**, three solar panels (**101**, **103**, **105**) are arranged in series according to a horizontal configuration. Such a configuration is purely exemplary, and it is to be understood that embodiments of the claimed subject matter are well suited to varying configurations and orientations. Panels may be configured in arrays in one (a row of panels) or two (a grid of panels) dimensions, for example.

Exemplary Frame Configurations

As depicted in FIG. **2**, an exemplary configuration **200** of a panel splice and frame is depicted, in accordance with various embodiments of the claimed subject matter. FIG. **2** depicts a cross-section of a panel **201**. The panel **201** includes a frame **202**. As depicted, the frame includes a first channel **203**, and

a second channel **205**. As shown in FIG. **2**, the first channel **203** may be used as a connection channel, and used to allow panel splices **209** to move along the channel into position to mechanically couple the panel to an adjacent panel, and/or out of position in order to decouple a pair of adjacent panels, for example. The second channel may be used to position a mounting point (e.g., mounting point **107** of FIG. **1**). According to further embodiments, the second channel can also be used to secure, or allow the movement and/or passage of various channel accessories. These channel accessories may include, for example, a series of cable clips fastening a plurality of cables together; an extra splice to reinforce or support a coupling of two adjacent panels; an electrical box, solar optimizer, micro inverter attachment, safety device, or performance enhancement device used during the process to convert absorbed solar energy into electricity, etc.

As depicted in FIG. **2**, panel splice **209** is shaped as a ridged bar. Panel splice **209** may be composed of metal, or any other high density and/or rigid composition capable of supporting the weight of two adjacent solar panels. While depicted as a ridged bar in FIG. **2**, panel splice **209** may be variously shaped, according to different embodiments. For example, panel splice **209** may also be shaped as a plate, rod, slider, beam, bolt, or other composition with a substantially straight profile. In alternate embodiments, the panel splice **209** may be shaped with a (slight) arched profile, such that the top of the arch crests at a location between two adjacent panels, and increasing the support provided by the splice **209**. In still further embodiments, the splice **209** may be shaped as any number of polyhedrons, not specifically limited to cylinders (rods). For example, embodiments may be well suited for implementations that impart a trapezoidal polyhedron shape to the panel splice **209**.

Also as depicted in FIG. **2**, panel splice **209** may be fastened at a position in the channel and the frame using a fastening mechanism **207**. Fastening the panel splice **209** to the frame may be performed by adjusting a fastening mechanism **207** in an aperture through the panel splice **209**. The fastening mechanism **207** may be implemented in a variety of manners, including, but not limited to: a bolt; a cam, a screw; an interference fit fastener; a threaded fastener; a tapered threaded fastener; a cone-threaded fastener; a ball-tipped fastener; a spring-loaded fastener; a pin; and a tapered spring fastener; or any other device that may be inserted through an aperture in the splice **209** and adjusted until movement of the splice is substantially prevented.

In one or more embodiments, the panel splice **209** may include multiple apertures, either implemented as complete through-holes, or raised ridges (or depressions) that correspond to similar structures or protrusions on one or more surfaces of the channel that assists in the guidance of the panel splice **209** into proper positioning. Alternately, a spring pin in the splice **209** and a corresponding pin hole in the interior surface of the channel can be implemented and used as an indication when the splice **209** is properly positioned. In further embodiments, the spring pin, when positioned within the pin hole also is configured to secure the splice in place. While FIG. **2** depicts a fastening device **207** being inserted through an aperture in a side surface of the splice **209**, according to alternate embodiments, the aperture for fastening the splice **209** may be located on a top surface, and fastening the aperture to the frame or a spacer component (described below) may be performed from a position above the panel **201** and splice **209**.

FIG. **3** depicts an exemplary configuration **300** of a panel **301** with a pair of panel splices (splices **309**, **311**), in accordance with various embodiments of the claimed subject matter. Panel **301** is depicted with an encircling frame **303** that includes two channels, channels **305**, **307**. Each channel is fitted to secure the movement of corresponding panel splices **309**, **311**. As shown in FIG. **3**, a first panel splice **309** is operable to travel the length of the top channel **305**, along the interior of the channel **305**. A second panel splice **311** is operable to travel the length of the bottom channel **307**, with a surface on an exterior of the channel **307** (and frame **303** itself). A dual splice system may be used to provide additional load-bearing support or rigidity, for example.

In one or more embodiments, one or more of the splices may also be equipped with one or more friction-reducing elements, so as to allow smoother movement along a channel. The friction-reducing element may be one of several possible implementations that include, but are not limited to: a surface finish; a surface coating; a surface plating; a plurality of surface grooves to reduce contact with channel surfaces; a plurality of other raised elements (e.g., bumps); embossing; encasing in a low-friction polymer; adhesion to a low-friction tape, etc.

FIGS. **4***a*-**4***c* depict cross-sections of varying exemplary panel frames, in accordance with various embodiments of the claimed subject matter. FIG. **4***a* depicts a cross-section of an exemplary panel frame **401***a* with three channels (**403***a*, **405***a*, **407***a*). FIG. **4***b* depicts a cross-section of an exemplary panel frame **401***b* with two channels (**403***b*, **405***b*). FIG. **4***c* depicts a cross-section of an exemplary panel frame **401***c* with one channel (**403***c*), in accordance with various embodiments of the claimed subject matter. As described above with respect to FIGS. **1**-**3**, one or more of the channels in each frame (**401***a*, **401***b*, **401***c*) may be used to transport, or position, one or more module splices to a location between two adjacent panels to provide structure, support, and a grounding path. Remaining, unoccupied channels may be used for various purposes as described herein.

As depicted in FIG. **5**, a cross-section **500** of an exemplary panel frame **501** and panel splice **509** is depicted with a shelf configuration **511**, in accordance with various embodiments of the claimed subject matter. As shown in FIG. **5**, the panel frame consists of three channels, one closed channel **503**, and two exterior facing open channels **505**, **507**. A panel splice **509**, depicted in FIG. **5** to include a shelf **511** may be inserted—at a corner of the panel frame **501**, for example—into the lower channel **507**. Subsequently, the panel splice **509** may be moved along the channel **507** until a portion of the panel splice **509** extends at least partially into a corresponding channel **507** in an immediately adjacent panel. In this manner, a portion of the panel splice **509** may protrude into channels **507** for both panels, with the panel splice **509** bridging a space between the panels. The portion protruding into each channel **507** may then be affixed to each panel (via each respective frame, for example) thereby aligning the panels, and providing rigidity and support to the panel array. A shelf **511** as depicted in FIG. **5** may be able to provide additional support and rigidity to the structure by preventing a slight dip or any other misalignment between adjacent panels.

Exemplary Fastening Device

FIGS. **6***a* and **6***b* depict cross-sections (**600***a*, **600***b*) of an exemplary panel frame **601** and panel splice **609**. Each of FIGS. **6***a* and **6***b* depict panel frames **601** in a three channel configuration, including a closed back channel **605**, a lower, open front channel **603**, and an upper open front channel (occupied by the splice **609**). In one or more embodiments, one or more channels of a panel frame **601** may be equipped with securing features to allow the secure movement of a panel splice **609** along the channel. These features may include, for example a bolstered edge (**613**) that corresponds

to a dovetail feature **615** of the panel splice **609**. Such a configuration secures the splice within the channel while still allowing free movement along the channel.

FIG. **6***a* depicts an adjustable fastening mechanism **611***a* at a less secured position. FIG. **6***b* depicts the adjustable fastening mechanism **611***b* at a more secured position. While the claimed subject matter is well suited to other embodiments, the fastening mechanisms **611***a* and **611***b* are depicted in FIGS. **6***a* and **6***b* as bolts that are inserted through apertures in side surfaces of both the panel splice **609** and a wall in the back channel **605**. Fastening the splice **609** into a current position may thus be performed by inserting the fastening mechanism into an initial position (e.g., **611***a*) and tightening the fastening mechanism to secure the splice **609** into place at a final position (e.g., **611***b*). While FIG. **6***a* depicts a side-oriented fastening embodiment, the apertures may also (or instead) be positioned on top surfaces of the panel splice **609** and frame **601***a*, **601***b*, such that the fastening device may be inserted through the apertures in the top surfaces and secured also from the top. Removal of top-fastened splices may be performed in these embodiments also from a position above the panels, thereby providing greater access to fastening mechanisms of installed panels arranged in tightly spaced, two-dimensional arrays.

Exemplary Integrated Electrical Connection Interfaces

FIG. **7** depicts an exemplary illustration **700** of a plurality of panels (**701**), each panel having an encircling frame (**703**), in accordance with various embodiments of the claimed subject matter. The panels **701** may be mechanically coupled to each other with panel splices **709** positioned along channels in the top and bottom edges of the frames **703** surrounding the perimeters of the panels **701**, as described above. As depicted in FIG. **7**, each panel **701** includes a pair of integrated electrical connection interfaces. In one or more embodiments, the electrical connection interfaces may include a reception interface **705** configured to mechanically and electrically couple (via a plurality of pins, for example) with a connection interface **707**. In one or more embodiments, coupling a reception interface **705** of a panel (e.g., **701**) with the connection interface **707** of a neighboring panel (e.g., **703**) establishes an electrical path between the panels, e.g., to conduct the flow of electricity along the configuration of panels.

As depicted in FIG. **7**, each electrical connection interface may be positioned to protrude from a side surface of a panel frame, and such that the reception interface of a panel is on an opposite side surface of the connection interface. In this manner, the reception interface of a panel is always aligned to couple with a connection interface of a neighboring panel, and vice versa. By having an integrated electrical connection interface in the panels themselves, conventional approaches that require sub-surface wiring underneath the panel can be avoided, such that removal of panels may be performed more easily, with greater access to the electrical path, and with less risk of exposing or damaging wiring during removal procedures. The electrical connection may be disengaged by decoupling the reception interface **705** from the connection interface **707**.

In one or more embodiments, disengagement of the electrical connection interfaces may be performed using a release feature **711**. The release feature may, in some embodiments, be implemented to include a mechanical release of one or more engagement features used to couple the electrical connection interfaces together. The engagement features may, in some instances, be implemented as: a spring action element; a clasping element; a latch element; a twist element; and/or a cam element, each of which, when the mechanical release is activated, releases the engagement between the connection interface **707** and the reception interface **705**. In one or more embodiments, the release feature **711** may be activated by hand (e.g., toggling a button or lever). In further embodiments, the release feature **711** may be activated with a general or specialized tool.

FIG. **8** depicts an exemplary illustration **800** of a plurality of coupled panels (**801**), each panel having an encircling frame (**803**), in accordance with various embodiments of the claimed subject matter. As depicted in FIG. **8**, the panels **801** correspond to the panels **701** described above with respect to FIG. **7**. The panels **801** are depicted in a coupled state, whereby a pair of panel splices **809** are positioned in channels along the top and bottom edges of the frames **803**, and affixed to the frame. As depicted in FIG. **8**, a roughly equivalent proportion of each splice may extend into a channel of each panel. The splices may be affixed to the frames via fastening mechanisms along the top and/or side surfaces, as variously described herein.

In one or more embodiments, spacer components **805** may be placed between panels, in order to provide a clearance between the pair of adjacent panels **801** and to allow access to a release feature **811** of an electrical connection **807**. In one or more embodiments, the spacer components **805** may be implemented to include a channel, aligned with the one or more channels of the panel frames **803**, and configured to allow a panel splice **809** to travel through the spacer channel. In other words, the spacer channel may act as a channel bridge in the space between the panels. Particular implementations of the spacer components **805** can vary widely across embodiments. These implementations may include, but are not limited to: a clamp; a washer; a bolt; a shelf; a full or partial cross-section of a frame; or any such component configured to align against an exterior (outwardly facing) surface of a frame **803** of a panel **801** and to provide a clearance between two adjacent panels **801**.

In one or more embodiments, the panel splices **809** may be fastened to a desired position through the spacer components **805**. For example, a fastening mechanism (such as fastening mechanism **611***a*, **611***b* described above with respect to FIGS. **6***a* and **6***b*) may be fastened to the panel splice **809** through an aperture in the top or side surface of the spacer component **805**. In alternate embodiments, tightening of the fastening mechanism may be performed through an aperture in the panel splice **809**, with the fastening mechanism gaining access to contact the panel splice **809** through an aperture in the top or side surface of the spacer component **805**. According to such embodiments, the fastening mechanism may or may not itself be fastened to the spacer component **805**.

FIG. **9** depicts an exemplary illustration **900** during the removal of a middle panel of a sequence of three panels (**901***a*, **901***b*, **901***c*), in accordance with various embodiments of the claimed subject matter. As depicted in FIG. **9**, each panel has an encircling frame (**903**). As depicted in FIG. **9**, the panels **901***a*, **901***b*, **901***c* correspond to the panels **701** and **801** described above with respect to FIGS. **7** and **8**. As shown in FIG. **9**, panel **901***b* may be removed by unfastening the panel splices **909** and moving (sliding) the panel splices **909** out of the channels in the frame **903** of the target panel **901***b*. Unfastening the panel splices **909** may be performed by removing or deactivating a fastening mechanism used to affix the panel splice **909** to a frame **903** and/or a spacer component **913**. For example, a bolt may be loosened through an aperture in either the side or top surface of a panel splice **909** and at least one of a frame **903** and a spacer **913** the panel splice **909** is affixed to.

In one or more embodiments, the panel splices **909** may be moved further into the channels of the adjacent panels **901***a*, **901***c*, such that an entirety or a substantial portion of each

panel splice **909** is in the neighboring panels, with little to no portion of the splice remaining in the panel **901***b* to be removed. In one or more embodiments, the panel splices **909** may be moved through the spacer components **913** with sufficient clearance as to allow the removal of the spacer components **913** from between the panels. In still further embodiments, a spacer component **913** may be removed (e.g., by removing a top-oriented fastening mechanism) without disturbing the placement of the panels on either side of the spacer component **913**.

Panel Installation

FIG. **10** depicts a flowchart of an exemplary process **1000** for coupling a plurality of panels. Steps **1001-1011** describe exemplary steps comprising the process **1000** in accordance with the various embodiments herein described.

At step **1001**, a panel is affixed to a mounting system. Affixing the panel to a mount may be performed by, for example, fastening a mounting point against a frame of the panel, and to the mounting system itself. According to various embodiments, the mounting point may be configured to freely travel a length of a side of the frame of the panel within a first channel or groove in the frame until a desired position is reached. The mounting point may then be fastened against the frame to secure the panel to the mounting system.

At step **1003**, a second panel is positioned next to the panel affixed to the mounting system. The second panel may be positioned linearly in a serial alignment with respect to the first panel, as part of a one or two dimensional array of panels, for example. Once positioned, a spacer is positioned between the two panels (step **1005**). In one embodiment, the spacer is positioned to align with the exterior surface of the frames of the adjacent panels along the edge of one side of the frames. A panel splice is then inserted into a second channel of one of the panels at step **1007**. According to alternate embodiments, the panel splice may be inserted into a second channel of the first panel prior to the positioning of the second panel at step **1003**.

Once the panel splice is inserted into a second channel in the frame of either the first or second panel, the panel splice can be moved along the second channel of one or both panel frames and the spacer at step **1009** until a target position is reached. In one embodiment, the target position is achieved when the panel splice extends into the second channel of both panel frames in substantially equivalent proportion. In further embodiments, bumps, spring-pins or other guiding elements (with corresponding apertures, grooves) may be used to guide the panel splice into proper positioning, indicate the splice is in the correct position, and further secure the splice in place. Once the target position of the splice is achieved, the splice can be fastened at step **1011**, e.g., via a fastening mechanism through a side and/or top surface of the splice, whereby the splice is affixed into its present position and to the spacer, at least one of the pair of adjacent panels, or any combination thereof.

Steps **1005** to **1011** are then repeated for an opposite edge of the pair of adjacent panels, whereby a second spacer is inserted between the panels, a second splice is inserted, positioned, and fastened into a target position. In further embodiments, each panel may further include an electrical connection interface that is configured to electrically and physically couple when a pair of adjacent panels are positioned and aligned. In one embodiment, positioning the splice at the target position (e.g., step **1009**) aligns the panels, and may position the electrical connection interfaces of each panel to automatically couple. In further embodiments, the alignment of the panels provided by the splice also prevents terminals (e.g., pins) of the interface from being damaged. Once splices on both opposite edges are fastened into position, and the electrical connection interfaces between the pair of panels is engaged, installation is completed for that pair of panels. A next panel in the series can be installed, adjacent to the second panel, by performing steps **1003** to **1011** for the panel, and for each subsequent panel in the series.

Panel Removal

FIG. **11** depicts a flowchart of an exemplary process for removing a panel between a plurality of adjacent panels, in accordance with various embodiments of the claimed subject matter. Steps **1101-1011** describe exemplary steps comprising the process **1000** in accordance with the various embodiments herein described.

At step **1101**, panel splices are unfastened for a target panel between a pair of panels, with a panel being located on either side of the target panel. Panel splices may be unfastened by loosening (and/or removing) a fastening mechanism affixing the splices to the frame of target panel and each of the two neighboring panels. At step **1103**, the splices along a top edge of the panels are moved in a channel along the frames of each of the target panel and the two neighboring panels such that no (substantial) portion of any splice remains in the channels of the target panel. This may be performed by, for example, shifting the splice so that an entirety or substantial majority of the splice extends into the channels of the neighboring panels, and away from the channel of the target panel. Movement of the splices is repeated at step **1105** for the splices in the channels along the bottom edge of the panels.

Once the splices are completely disengaged from the target panel along both the top and bottom edge, electrical connectors coupling the target panel to electrical connectors in each of its neighboring panels are also disengaged at step **1107**. Disengaging the electrical connectors may be performed, for example, by activating a release element in the electrical connector that automatically releases, or allows a manual separation of the electrical interfaces coupled together to form the electrical connection. At step **1109**, the target panel is unfastened from the mounting system (if necessary), by detaching or unfastening the target panel from a mounting point. Thereafter, the target panel is no longer attached to either of the adjacent panels mechanically or electrically, and any attachment to the mounting system is removed as well. Finally, the target panel may be removed at step **1111**.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed is:

1. An installation system for a plurality of panels, the system comprising:

a plurality of panels, each panel of the plurality of panels comprising:

a frame encircling a perimeter of the panel;

a first channel disposed along the frame, the first channel being configured to affix the panel to a plurality of mounting points;

a second channel disposed along a surface of the frame and defining a channel opening extending along the surface of the frame; and

a plurality of panel splices operable to mechanically secure a pair of adjacent panels of the plurality of panels when a first portion of a panel splice is affixed to a frame of a first panel of the two adjacent panels and a second por-

tion of the panel splice is affixed to a frame of the second panel of the two adjacent panels,

a plurality of spacer components, wherein a pair of spacer components of the plurality of spacer components is configured to be physically disposed between a pair of opposite, parallel, edges of the frames corresponding to a pair of adjacent panels; and

a spacer channel disposed in each spacer component of the plurality of spacer components, the spacer channel being configured to align with the second channels of the pair of adjacent panels and to bridge a width of the spacer component between the second channels, the spacer channel sized to slidably receive the panel splice, the spacer channel having the panel splice positioned therein having the panel splice extending into the second channel of a first panel of the pair of adjacent panels and the second channel of a second panel of the pair of adjacent panels having the spacer positioned between the first and second panels;

wherein a panel splice is further operable to traverse an entire length of a side of a frame of a panel along a second channel of the panel for alignment thereof.

2. The system according to claim **1**, wherein each panel of the plurality of panels comprises one or more of solar cells.

3. The system according to claim **2**, wherein the one or more solar cells comprise at least one solar cell selected from the group of solar cells consisting of:

a plurality of silicon solar cells;

a plurality of crystalline solar cells;

a plurality of thin-film solar cells;

a plurality of amorphous solar cells; and

a multi-composition solar cell.

4. The system according to claim **1**, wherein the surface of the frame comprises at least one of:

an exterior surface of the frame;

a top surface of the frame;

a bottom surface of the frame;

a side surface of the frame; and

an interior surface of the frame.

5. The system according to claim **1**, wherein the frame further comprises a plurality of integrated electrical interfaces configured to couple with each other to provide an electrical path between a pair of adjacent panels.

6. The system according to claim **5**, wherein the plurality of integrated electrical interfaces comprises:

a connection interface disposed on a first side surface of the frame; and

a reception interface disposed on a second side surface of the frame, the second side surface of the frame being an opposite side of the frame from the first side surface of the frame,

wherein a connection interface of a first panel of a pair of adjacent panels is operable to physically couple to a reception interface of a second panel of the air of adjacent panels,

further wherein an electrical path between the first and second panels is generated when the connection interface of the first panel is physically coupled to the reception interface of the second panel.

7. The system according to claim **6**, wherein the panel splice is further configured to align the pair of adjacent panels during an installation of the pair of adjacent panels such that damage to the plurality of integrated electrical interfaces is substantially prevented during the installation.

8. The system according to claim **6**, further comprising an engagement feature to physically couple the connection interface of the first panel with a reception interface of the second panel, wherein the connection interface of the first panel is decoupled from the reception interface of the second panel by activating a release element of the engagement feature disposed on at least one of: the connection interface and the reception interface.

9. The system according to claim **8**, wherein the engagement element comprises at least one element from the group consisting of:

a spring action element;

a clasping element;

a latch element;

a twist element; and

a cam element.

10. An installation system for a plurality of panels, the system comprising:

a plurality of panels, each panel of the plurality of panels comprising:

a frame encircling a perimeter of the panel;

a first channel disposed along the frame, the first channel being configured to affix the panel to a plurality of mounting points;

a second channel disposed along a surface of the frame; and

a plurality of panel splices operable to mechanically secure a pair of adjacent panels of the plurality of panels when a first portion of a panel splice is affixed to a frame of a first panel of the two adjacent panels and a second portion of the panel splice is affixed to a frame of the second panel of the two adjacent panels,

wherein a panel splice is further operable to traverse an entire length of a side of a frame of a panel along a second channel of the panel for alignment thereof;

a plurality of spacer components, wherein a pair of spacer components of the plurality of spacer components is configured to be physically disposed between a pair of opposite, parallel, edges of the frames corresponding to the pair of adjacent panels; and

a spacer channel disposed in each spacer component of the plurality of spacer components, the spacer channel being configured to align with the second channels of the pair of adjacent panels and to bridge a width of the spacer component between the second channels, the spacer channel sized to slidably receive the panel splice, the spacer channel having the panel splice positioned therein having the panel splice extending into the second channel of a first panel of the plurality of panels and the second channel of a second panel of the plurality of panels having the spacer positioned between the first and second panels.

11. The system according to claim **10**,

wherein a gap is created between the pair of adjacent panels in an area between the pair of spacer components, the gap providing access to the engagement element

further wherein, a spacer component provides a surface against which to tighten a pair of adjacent panels.

12. The system according to claim **10**, wherein a spacer component is removable from a position between a pair of frames of a pair of adjacent panels without removing either of the pair of adjacent panels.

13. The system according to claim **10**, wherein the spacer component comprises at least one from the group consisting of:

a clamp;

a washer;

a bolt;

a shelf;

a full cross-section of a frame;

a partial cross-section of a frame; and

a component configured to align against an exterior surface of a frame of a panel and to provide a clearance between two adjacent panels of the plurality of panels.

14. The system according to claim **10**, wherein a panel splice of the plurality of panel splices comprises a first plurality of apertures, wherein the panel splice may be affixed to a position via a fastening device through at least one aperture of the first plurality of apertures;

wherein the second channel includes an opening extending along the surface of the frame; and

wherein the panel splice is further operable to traverse an entire length of a side of a frame of a panel of the plurality of panels along a second channel of the panel for alignment thereof, the fastening device being accessible through the channel opening along an entire length of the channel opening and slidable within the channel opening with sliding of the panel splice within the second channel, the panel splice not protruding out of the channel opening when positioned within the second channel.

15. The system according to claim **14**, wherein at least one aperture of the first plurality of apertures is disposed on at least one of the group consisting of:

a top surface of the panel splice;

a bottom surface of the panel splice;

an interior surface of the panel splice.

16. The system according to claim **15**, wherein the fastening device is configured to be secured to the panel splice through an aperture disposed on at least one aperture of the first plurality of apertures.

17. The system according to claim **16**, wherein the plurality of spacer components comprises a second plurality of apertures, further wherein the fastening device is configured to be inserted through an aperture in a spacer component and secured to the panel splice.

18. The system according to claim **14**, wherein the fastening device comprises at least one fastening device from the group comprising:

a spring loaded pin;

a bolt;

a cam device;

a screw;

an interference fit fastener;

a threaded fastener;

a tapered threaded fastener;

a cone threaded fastener;

a ball-tipped fastener;

a spring loaded fastener;

a pin; and

a tapered spring fastener.

19. The system according to claim **1**, wherein the second channel comprises a securing mechanism configured to secure a panel splice during movement of the panel splice along the second channel.

20. The system according to claim **19**, wherein the securing mechanism comprises at least one of:

a bolstered channel in the second channel; and

a dovetail groove disposed on a panel splice.

21. The system according to claim **14**, wherein at least one of a spacer component and a panel splice positioned between a pair of adjacent panels is operable to provide a grounding path for the pair of adjacent panels.

22. The system according to claim **1**, wherein a panel splice of the plurality of panel splices comprises at least one from the group consisting of:

a plate;

a rod;

a slider;

a beam;

a bolt;

an arch;

a polyhedral extension; and

a stamped and bent metal plate.

23. The system according to claim **1**, wherein the plurality of panel splices comprises a friction-reducing element, the friction-reducing element comprising at least one from the group comprising:

a surface finish;

a surface coating;

a surface plating;

a plurality of surface grooves;

a plurality of raised elements;

an embossing;

an encasing in a low friction polymer;

a low friction tape.

24. The system according to claim **1**, wherein the first channel is further configured to provide mounting for a plurality of channel accessories, the plurality of channel accessories comprising at least one from the group of:

a plurality of cable clips operable to fasten a plurality of cables together;

an additional panel splice of the plurality of panel splices to provide structural reinforcement;

an electrical box attachment;

a micro inverter attachment;

a solar optimizer;

a safety enhancement device; and

a performance enhancement device.

25. A method for coupling a plurality of panels, the method comprising:

a) affixing a first panel to a mounting via a fastener disposed in a first channel of a frame surrounding the first panel;

b) positioning a second panel adjacent to the first panel in a serial alignment;

c) positioning a spacer component between the first panel and the second panel, the first spacer component in physical contact with both the first panel and the second panel along an edge of the frame of the first panel and an edge of a frame surrounding the second panel;

d) inserting a panel splice into at least one of: a second channel disposed in the frame of the first panel, and a second channel disposed in the frame of the second panel;

e) moving the panel splice through the second channel of the second panel and a spacer channel comprised in the spacer component until a portion of the panel splice extends into a second channel of the first panel and a second portion of the panel splice extends into the second channel of the second panel; and

f) fastening of the panel splice to spacer,

wherein steps c).-f). are performed for a first edge of the panel and a second edge of the panel opposite of the first edge.

26. The method according to claim **25**, wherein the b) positioning the second panel adjacent to the first panel comprises:

coupling a first electrical connector interface disposed in a side surface of the first panel to a second electrical connector interface disposed in a side surface of the second panel,

wherein the side surface of the first panel faces the side surface of the second panel.

27. A method for removing a panel between a plurality of adjacent panels, the method comprising:

unfastening a plurality of panel splices from a plurality of spacers positioned adjacent panels, the plurality of adjacent panels comprising a first panel, a second panel, and a third panel, wherein the second panel is positioned between the first panel and the third panel;

sliding, via a plurality of connection channels comprised in each of the first, second, and third panels, a first pair of panel splices from the plurality of panel splices comprised between the first panel and the second panel such that the first pair of panel splices moves from a first position to a second position, wherein in the first position each of the first pair of panel splices extends into the connection channel of the first panel and the connection channel of the second panel and through a spacer channel of a spacer of the plurality of spacers positioned between the first and second panels to a second position wherein in the second position at least a substantial portion of each of the first pair of panel splices extends into the connection channel of the first panel and no portion of the first pair of panel splices extends into the connection channel of the second panel;

sliding a second pair of panel splices from the plurality of panel splices comprised between the second panel and the third panel such that at least a substantial portion of the second pair of panel splices extends into the connection channel of the third panel and no portion of the second pair of panel splices extends into the connection channel of the second panel; and

removing the second panel.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,231,518 B2
APPLICATION NO. : 14/059190
DATED : January 5, 2016
INVENTOR(S) : Barry Cinnamon et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 15, Claim 27, Line 4 should read:

spacers positioned between adjacent panels, the plurality of

Signed and Sealed this
Twenty-fourth Day of May, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office